Low-cost Biodiesel Production Process Using Waste Oils and Fats

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Problem Statement

Biodiesel is a fuel that is made from processing vegetable oil or animal fats (triglycerides) into a liquid fuel that can be combusted in a standard diesel engine with no modifications. The vegetable oil or fat is "split" into three smaller fatty acid molecules with molecular lengths of about C_{14} to C_{20}, to lower the molecular weight of the oil. The fatty acids cannot be used as a fuel without further modification because they have high pour points (they can be solid at storage temperatures) and they are acidic and corrode engine parts. However, a simple esterification reaction between an alcohol and a fatty acid forms "biodiesel", or fatty acid alkyl esters. These compounds are liquid, non-acidic and burn nearly the same as petroleum diesel.

The growth of the biodiesel industry is limited because the current production processes requires a highly refined (expensive) low free fatty acid vegetable oil, typically derived from soybeans. Current processes can tolerate a feedstock with only 0.5% free fatty acid or less.

In addition to the problem of high free fatty acids, low-cost feedstocks from greases and food wastes tend to be high in saturated fats, and therefore they have a higher gel point. This higher gel point (melting point) results in a biodiesel product that has poor cold temperature properties. Thus, in this proposed process we will be addressing this issue by modifying the chemical structure of the biodiesel so that the gel point is lowered, making a higher quality fuel.

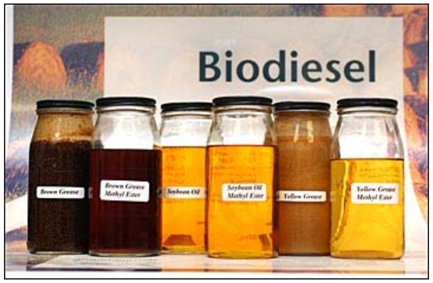

Photo credit: Iowa State Website
www.iastate.edu/Inside/2003/0613/biorenewable.jpg

Technology Description

The proposed project will develop, test and evaluate a new process for producing biodiesel from much less expensive high free fatty acid (FFA) vegetable oil and animal fat feedstocks. This process will be able to use less expensive feedstocks that cannot be converted to biodiesel with current methods. The new process will promote increased use of biodiesel by reducing the cost of the fuel, while at the same time converting waste materials to a renewable liquid fuel. Additionally the new process will be more energy efficient and will not produce aqueous waste as a result of high concentrations of free fatty acids like current processes.

The process is based on proprietary technology that supports large-scale continuous operation. As with all commodity chemicals, including liquid fuels, the feedstock costs make up the majority of the product's price. This process addresses two critical needs for future expansion of the domestic biodiesel industry: First, without government tax credits biodiesel cannot compete with petroleum derived Diesel #2 on a cost basis until crude petroleum exceeds roughly $80 per barrel. This figure is highly dependant on the cost of soybean oil, but at current market conditions biodiesel still costs significantly more. Second, U.S. soybean production is rapidly being consumed by the existing biodiesel industry and new feedstock sources are required for further increased capacity.

Photo credit: Consolidated Biofuels Website
http://www.cbiointl.com/

Expected Results

The expected results include the development of a new chemical conversion process that can tolerate oil and fat feedstocks which contain high levels of free fatty acids. These feedstocks are typically treated as waste materials because they have very little value. The fatty acid content is at least 2% and can be as high as 70%. Examples of these feedstocks include yellow grease, brown grease, meat rendering wastes, inedible vegetable oils and acidulated soap stock.

Feedstock costs for biodiesel made from this proposed process are about $1.10 to $2.01 per gallon of biodiesel product, which is at least $0.69 lower per gallon of product than a conventional soybean oil fatty acid methyl esters biodiesel product (Soybean oil FAME).

Waste oils and fats also tend to be highly saturated and as a result offer the benefit of high cetane number (CN). This CN is the quality rating scale for the combustion properties of diesel fuel much like octane number is the quality rating for gasoline. Thus, our use of these feedstocks, combined with the chemical modification to improve cold temperature performance, should result in a premium quality fuel with a CN of over 90.

An example of a fully automated pilot-scale apparatus used to evaluate new chemical conversion processes at TDA Research.

Potential Environmental Benefits

The potential environmental benefits of using biodiesel instead of petroleum derived diesel #2 include a reduction in the the generation of greenhouse gasses. Biodiesel is produced from renewable sources, either plant or animal. This project seeks to develop a new production process that will allow the domestic biodiesel market to expand by decreasing the fuel's cost and expanding the potential feedstock sources.

In particular, the use of biodiesel does not generate any net CO_2 emissions. It is also a very low sulfur fuel, reducing acid rain.

Biodiesel is biodegradable and in the event of a fuel spill there are fewer long-term environmental effects compared to petroleum products.

Biodiesel can be produced from domestic feedstocks. Materials only need to be transported locally, thus reducing the energy consumption, and corresponding pollution, required to manufacture the fuel.

The Life Cycle Analysis indicates that in addition to the environmental benefits of using the biodiesel fuel, the new production process has less impact on the environment than the existing biodiesel production process.

Photo credit: Consolidated Biofuels Website
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